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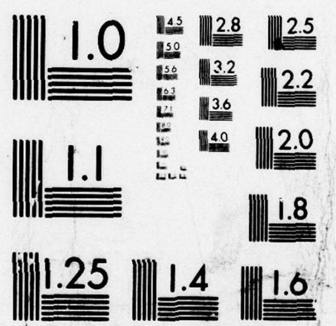

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THE GENERAL AVIATION DYNAMICS MODEL

Volume I. Executive Summary

July 1979

FINAL REPORT

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Office of Aviation Policy
Aviation Forecast Branch
Washington D.C. 20591

The contents of this report reflect the views of Battelle's Columbus Laboratories, which is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policy of the Department of Transportation. This report does not constitute a standard, specification, or regulation.

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16. Abstract

The model is a dynamic simulation, interactive computer, model built upon the cause-effect interactions displayed between various sectors of the general aviation system. The initial work by Battelle in 1976 was based on data through calendar year 1974 (Report No. FAA-AVP-77-20, General Aviation Dynamics ..., April 1977, three volumes).

Under this contract, the model was updated based on data through 1976 and the results are presented in a two volume technical document covering the current model development efforts and all prior work done by Battelle.

BEGIN HERE

Volume I: Executive Summary-provides a brief non-technical overview of the General Aviation Dynamics ~~(GAD)~~ model, an evaluation of its first post-sample period forecast, and a discussion of some of its more recent applications, are given.

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FINAL REPORT

on

THE GENERAL AVIATION DYNAMICS MODEL

VOLUME I. EXECUTIVE SUMMARY

to the

OFFICE OF AVIATION POLICY
FEDERAL AVIATION ADMINISTRATION

May 30, 1979

by

Michael A. Duffy
Jane H. McCreery, Ph.D.

(CONTRACT NO. DOT-FA77WA-4043)

BATTELLE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

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INTRODUCTION

The United States general aviation fleet is comprised of all civil aircraft except those operated by the commercial air carriers. General aviation has had a tremendous influence on the American way of life: in travel time, in technology, in jobs, in fulfilling the transportation needs of a mobile society. By virtually any standard, the general aviation system within the United States is a large, diverse, and complex group of people, equipment, and activities. It encompasses a fleet of over 178,000 aircraft, flying nearly 4-1/2 billion miles, consuming more than 900 million gallons of fuel, and performing over 100 million operations during 1976.(1)

Much of its influence, nevertheless, remains noticeably misunderstood and unexplored. A comprehensive definition of general

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(1) FAA Statistical Handbook of Aviation--Calendar Year 1976.

aviation by the Federal Aviation Administration (FAA) is "the use of aircraft for purposes other than commercial transportation certificated by the Civil Aeronautics Board, intrastate commercial operations by large aircraft on regularly scheduled routes, or military use". Commuter airlines and air taxi operations are included in the term general aviation. In contrast to the interest shown in the activities of the commercial airlines, general aviation has been largely ignored by analysts outside of the FAA and the industry itself. The lack of scholarly attention to general aviation is surprising when one considers its importance. This importance is substantiated by any conceivable measure one cares to make, whether number of aircraft, mileage or hours flown, landings and take-offs, industry employment, net exports, etc.

Accurate forecasts of general aviation activity are important to the FAA, the manufacturers of general aviation aircraft and equipment, fuel suppliers, and airport operators. The FAA relies on short-term forecasts of national aviation activity to support the budgetary process, whereas long-term forecasts are used in the research and development planning process. Of primary importance is an accurate assessment of the expected future growth of general aviation. These forecasts, already complex, become extremely difficult when evaluating possible alternative federal policies.

Forecasts are a necessary input to the policy evaluation process, but a thorough planning exercise requires more. Policy evaluation requires models which describe the cause-effect relationships characteristic of actual decision processes in the real system. In order to properly evaluate alternative policy actions, a comprehensive understanding of the system is required and adequate flexibility in its representation is desired.

Development of the General Aviation Dynamics (GAD) model is the result of a series of research programs conducted by Battelle's Columbus Laboratories. Past studies concentrated on developing a consistent data base and methodology for determining the cost elasticity on both the general aviation fleet size and the annual hours flown. However, the inability of the resultant elasticities to adequately explain general aviation behavior during the turbulent

mid 70's, suggested that a different approach was needed to describe the complex nature of the general aviation system.

The GAD model is a dynamic simulation model built upon the cause-effect interactions displayed between various sectors of the general aviation system. It was first conceived and formulated under Contract No. DOT-FA 74WA-3485. A four volume report was published which described that model development effort, the data used, and a user's guide to "running" the GAD model:

General Aviation Dynamics:
An Extension of the Cost Impact Study
to Include Dynamic Interactions in the
Forecasting of General Aviation Activity
Report No. FAA-AVP-77-20
April, 1977

This initial work was based on actual general aviation activity data through CY 1974.

The current contract (Contract No. DOT-FA77WA-4043) originally called for forecast comparisons and model update based on actual general aviation activity during 1975 only. However, since the 1976 data were available during the conduct of this program, these additional data were included in the analyses. Furthermore, as a result of comments received from the FAA's review of the Interim Report, it was decided to modify the scope of this contract such that a single comprehensive technical document would be produced, covering the model development efforts within both Contract No. DOT-FA74WA-3485 and Contract No. DOT-FA77WA-4043.

This first volume of the final report, the Executive Summary, provides a brief non-technical overview of the GAD model, an evaluation of its first post-sample period forecast, and a discussion of some of its more recent applications.

Volume II, the Technical Report, is a detailed description of the development of the GAD model. It contains a complete set of statistics, including actual data, for the estimated causal relationships within each sector of the model. Volume II also illustrates how the GAD

model can be used to evaluate alternative policy actions in an uncertain future socioeconomic environment.

Volume III, the Systems Manual, provides a thorough description of the computer software aspects of the GAD model. This includes a complete listing of the program, an example of a batch run of the model, a user handbook for the NUCLEUS programming language, and a user's guide for running the GAD model interactively. See Note on Page 25.

Background

The FAA, recognizing the need for improved methods of forecasting and policy evaluation, contracted with Battelle's Columbus Laboratories in October, 1975, to develop a dynamic simulation model of the general aviation system.

Prior to this effort, forecasts of general aviation activity were based on a "top-down" approach; that is, national totals were estimated and subsequently divided into various sectors of interest. Oftentimes, simple trend extrapolation was used in developing these forecasts. Although forecasts produced by trend extrapolation and aggregate analyses may be adequate for some applications, acceptable policy evaluations, which introduce heretofore unknown disturbances, depend on a better understanding of system behavior.

In order to capture the different behavior exhibited by the various users of general aviation, the data were disaggregated by seven distinct user categories and seven different aircraft types. The resultant 49 different possible combinations are shown in Table 1. However, only 29 of these subsegments of general aviation have had significant amounts of activity. Annual values for the active number of aircraft within each of these subsegments and the number of hours flown have been developed for calendar years 1970 through 1976.

The supply and demand for general aviation and general aviation services is subject to pricing levels, similar to other consumer goods.

However, the price elasticity of general aviation is especially complex because of the wide variety of uses represented by

TABLE 1. SIGNIFICANT GENERAL AVIATION SUBSEGMENTS

User Category I \ Aircraft Type J	1	2	3	4	5	6	7
1		X		X	X		X
2		X				X	
3		X		X	X		X
4	X			X	X		X
5		X		X	X		X
6		X					
7		X					

User Categories

1. Business Transportation
2. Corporate Transportation
3. Personal Flying
4. Aerial Application
5. Instructional Flying
6. Air Taxi
7. Other

X - Denotes insignificant activity

Aircraft Types

1. Single-Engine Nonaerial
2. Single-Engine Aerial
3. Multiengine Piston
4. Turboprop
5. lurbojet
6. Piston-Engine Helicopter
7. Turbine-Engine Helicopter

the many segments of the general aviation community. For example, a uniform fuel price change may have significantly different impacts on personal flying versus business flying. The basic reason for these differential impacts is that cost is only one of many factors affecting activity. Within different subsegments of general aviation, combinations of factors are present and cost, as only one of these factors, has a different relative importance. Thus, any cost impact analysis which treats general aviation as a homogeneous group cannot produce valid results.

Under two earlier contracts (Contract Nos. DOT-FA72-WA-3118 and DOT-FA74-W-3485), Battelle developed the data base so desparately needed to conduct a quantitative analysis of general aviation.

In order to properly evaluate the relative magnitudes of various user charges on general aviation, cost centers were defined for both the variable cost of aircraft operation and the fixed cost of aircraft ownership. Individual cost centers are designated in Table 2.

TABLE 2. COST CENTERS FOR GENERAL AVIATION AIRCRAFT

Variable Costs ($/hour)

- Fuel and Oil
- Airframe and Avionics Maintenance and Overhaul
- Engine Maintenance and Overhaul

Fixed Costs ($/year)

- Annualized Investment
- Hull Insurance
- Liability and Medical Insurances
- Hangar, Storage and Tie Down
- Federal Registration Fee and Weight Tax
- Miscellaneous

Results of a 1975 general aviation activity survey, conducted by the Civil Air Patrol for the FAA, have been used for estimating the number of IFR flight plans filed and the number of both local and itinerant operations.

Methodology

Policy models normally fall within the general class of causal descriptive models. Two of the better known methodologies are econometrics and system dynamics.

Econometric forecasting models emphasize the use of empirical data. An econometric model literally grows out of the data. Specification of the equations, estimation of the coefficients, testing of the model, all hinge on having a full set of data available on both

the endogenous and exogenous variables. The availability of formal data is, therefore, a critical factor to the econometrician in deciding what variables to include.

Econometric modeling makes extensive use of time series data. Although the existence of such data has stimulated the development of econometric models of the national economy, the lack of data has been an impediment to useful econometric model building elsewhere—especially within the general aviation system.

The classical system dynamics approach focuses on structuring the cause-effect relationships underlying system behavior, rather than developing extensive empirical data. It has relied heavily on perceptive insight and bold assertion, conditioned by time series data only insofar as they have been absorbed by the modeler. The system dynamicist chooses variables and structures equations because of their believed behavioral significance, not on the basis of whether reliable data exist. By emphasizing the internal mechanisms that produce change, a better understanding of system behavior is sought.

The development of models for forecasting (and evaluating policies general aviation activity under alternative future environments has been severely hampered by the lack of extensive data. As a result of these data limitations, previous (often econometric) methods have fallen short of the desired results. It is not that the methods and objectives of econometric analysis are not applicable to the general aviation system, but that the results have been disappointing. The data are definitely deficient, and as a result, recent econometric models of general aviation have been grossly simplified, statistically incorrect, and poorly communicated. Improper application of econometric techniques has been the main problem.

Nevertheless, planning for the future of general aviation cannot wait until adequate data are assimilated. Alternative policy actions need to be formulated now and evaluated with the best information and understanding currently available.

Econometrics has been unsuccessful and classical system dynamics lacks the mathematical and statistical rigor which is certainly

desirable. The approach used in development of the General Aviation Dynamics model is a hybrid of econometrics and system dynamics. Using the best attributes of both, the general aviation system was modeled by simultaneously considering the underlying structure, the data requirements, and data availability.

During model development, the main consideration was in identifying the important system variables and how they interact, not only with exogenous factors, but also among themselves. Preservation of these dynamic interactions within general aviation is a significant difference between the GAD model and previous econometric applications. This is not to say that econometric regression techniques were not used in quantifying certain functional relationships in the GAD model. However, instead of applying regression analysis directly to the absolute level of state variables (e.g., active pilots, active aircraft, etc.), it was the rates of flow into and out of these levels that were estimated. Structurally, the GAD model is a nationally aggregated set of finite difference equations. These difference equations represent the actions continuously taking place within the general aviation system--airman certificates being issued, aircraft being activated, etc.

Recognizing the versatility of this modeling technique, a computer-based dynamic simulation of modeling system, NUCLEUS, has evolved as a result of numerous multidisciplinary research projects at Battelle. Through NUCLEUS, the GAD model is available on-line at both Battelle and an FAA vendor's computer. GAD can be accessed on either machine via telephone from anywhere in the U.S., using either a remote batch terminal or an interactive terminal.

AN OVERVIEW OF THE MODEL

In developing the General Aviation Dynamics model, a system boundary was chosen which defines the mechanisms that foster the growth of general aviation activity. This activity is the result of continuous causal interactions between three major sectors of general aviation: pilot supply, aircraft demand, and aircraft utilization. These three sectors interact in multiple ways, as illustrated on the system structural diagram in Figure 1. Failure to recognize these interactions, is equivalent to assuming that behavior within each sector is independent of conditions within any other sector. The interactions between these sectors form the basis for developing a better understanding of the general aviation system--an understanding which can lead to more formative policy making.

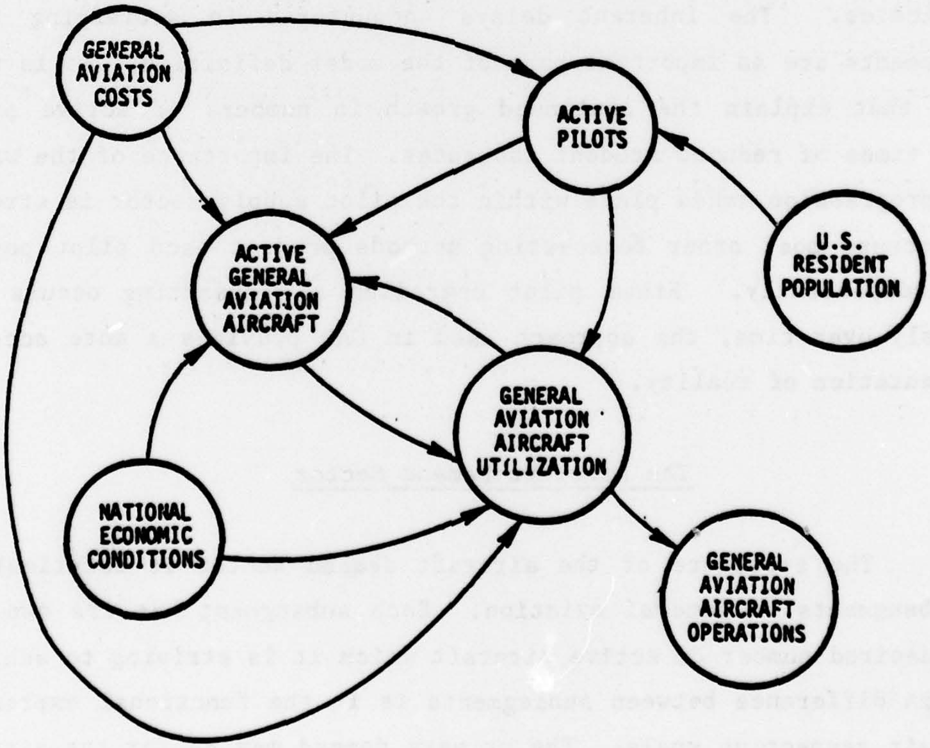

FIGURE 1. STRUCTURE OF THE GAD MODEL

The Pilot Supply Sector

The number of active airmen is an important element in determining the demand for aircraft, owned and operated by the same individual. Typically, these are business and personal aircraft. The pilot supply sector develops forecasts of the active pilot population by type of certificate. It also projects the number of both instrument and helicopter ratings (Figure 2).

The controlling factor in determining ultimate pilot population is the rate of student certificate issuances. By dividing the U.S. population over 16 years old into three distinct age groups, recent data can be used to show a definite relationship between student certificates issued, population, and relative cost of instructional flying.

A valid description of the pilot supply sector must recognize the required progression of steps necessary to qualify for advanced certificates. The inherent delays encountered in satisfying these requirements are an important part of the model definition. It is these delays that explain the continued growth in numbers of active pilots during times of reduced student issuances. The importance of the way in which progression takes place within the pilot supply sector is stressed here because most other forecasting methods project each pilot population independently. Since pilot upgrading and departing occurs continuously over time, the approach used in GAD provides a more accurate representation of reality.

The Aircraft Demand Sector

The structure of the aircraft demand sector is identical for all subsegments of general aviation. Each subsegment has its own goal for a desired number of active aircraft which it is striving to achieve. The main difference between subsegments is in the functional expression for their respective goals. The primary demand may be for the aircraft itself or only for the service provided by the aircraft.

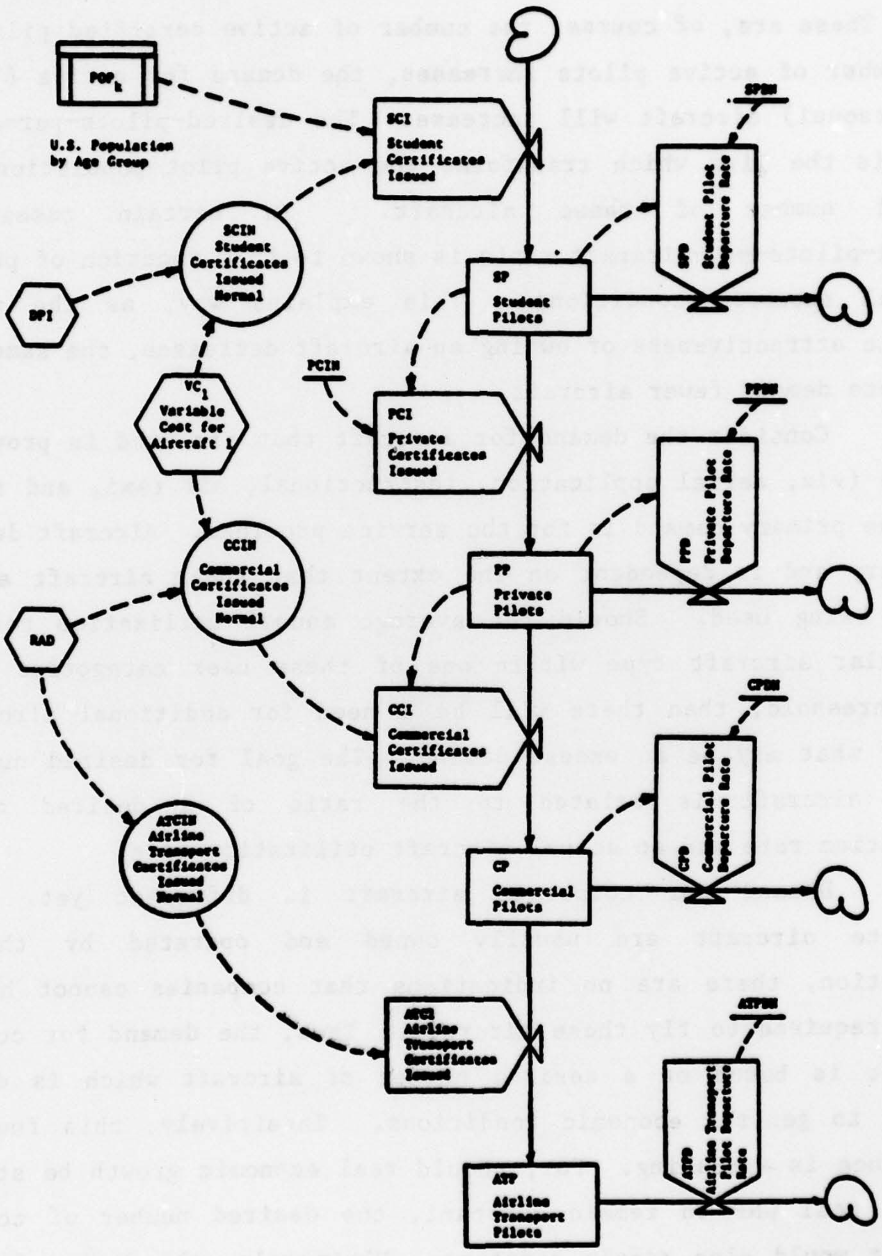

FIGURE 2. PILOT SUPPLY SECTOR

The demand for aircraft that are owned and operated by the same individual (viz, business and personal use categories) is a primary demand which is likely to be dependent on the supply of such individuals. These are, of course, the number of active certified pilots. As the number of active pilots increases, the demand for active (business and personal) aircraft will increase. The desired-pilots-per-aircraft ratio is the link which transforms the active pilot population into a desired number of these aircraft. In certain cases, this desired-pilots-per-aircraft ratio is shown to be a function of price and national economic conditions. This explains why, as the relative economic attractiveness of owning an aircraft decreases, the same number of pilots demand fewer aircraft.

Consider the demand for aircraft that are used in providing a service (viz, aerial application, instructional, air taxi, and rental). Here the primary demand is for the service provided. Aircraft demand is secondary and is dependent on the extent that these aircraft are presently being used. Should the average annual utilization rate of a particular aircraft type within one of these user categories surpass some threshold, then there will be a need for additional aircraft to satisfy what may be an excess demand. The goal for desired number of active aircraft is related to the ratio of a desired aircraft utilization rate and an actual aircraft utilization rate.

Demand for corporate aircraft is different yet. While corporate aircraft are usually owned and operated by the same corporation, there are no indications that companies cannot hire the pilots required to fly these aircraft. Thus, the demand for corporate aircraft is based on a desired number of aircraft which is directly related to general economic conditions. Intuitively, this functional dependence is appealing. For, should real economic growth be stagnated causing real GNP to remain constant, the desired number of corporate aircraft would also remain constant. Ultimately, the demand for additional corporate aircraft would represent only replacement of destroyed aircraft. However, if the economy continues to grow, an ever increasing number of active corporate aircraft will be desired.

The Aircraft Utilization Sector

These different behavioral subsegments are also evident within the aircraft utilization sector. First is the owner-operator situation, characterized by the business and personal use categories. Here an aircraft is purchased and operated by the same individual. The average annual utilization rate for these aircraft has been varying about a nominal value. Thus, total annual utilization within each subsegment is obtained by taking the product of active aircraft and average annual utilization rate.

Demand for aerial application, instructional, and air taxi flying represents an aggregate demand for a general aviation service. The total annual hours demanded are distributed among the available aircraft to determine a derived annual utilization rate. These derived utilization rates are used in determining the demand for additional aircraft in these categories.

Different user category/aircraft type subsegments respond to different stimuli. Utilization, either average rate or total hours, has shown a significant correlation with variable cost of operation in only a few of the 29 segments. Some subsegments have indicated utilizations dependent on GNP, DPI, or the level of commercial air activity.

The projected level of annual hours flown is used to determine the corresponding number of local and itinerant operations within each subsegment. Annual hours flown is also used in calculating the amount of both piston and jet fuel consumed.

The Dynamics of Aircraft Demand

The structure of the aircraft demand sector is identical for all subsegments of general aviation but, because of the various uses of general aviation aircraft, the desired stock of active aircraft is determined differently for different users. At any point in time, each

subsegment has both an actual number of active aircraft and a desired number of active aircraft which it is striving to achieve. This desired stock can be greater than, less than, or equal to the actual number of active aircraft, depending upon conditions within other sectors of the system. Of special interest in explaining annual fluctuations in aircraft activation is the role of pilot population, average aircraft utilization rates, and exogenous economic parameters.

The demand for aircraft is a derived demand, the primary demand being for transport services provided by the aircraft. This derived demand is demand for a stock (or goal) of aircraft, not for the flow of aircraft activations. The goal, desired-active-aircraft (DAA), can be a complex function of the number of pilots, the average aircraft utilization rate last year, fixed costs, variable costs, and exogenous inputs for Gross National Product (GNP) or Disposable Personal Income Per Capita (DPI). For any particular subsegment, if the stock of aircraft desired is greater than the current number of active aircraft within that subsegment, then additional aircraft will be activated; otherwise, aircraft would be deactivated. Thus, the dynamics within the general aviation system are the result of continuous causal interactions between the pilot supply sector, the aircraft utilization sector, and the aircraft demand sector.

To illustrate, consider the demand for business single-engine aircraft, displayed in Figure 3. DPPA, desired-pilots-per-aircraft, relates the demand for business aircraft to the number of active pilots. The goal for active aircraft DAA, desired-active-aircraft, is simply

$$DAA = \frac{TP}{DPPA}$$

where TP (total pilots) is equal to the sum of private plus commercial plus airline transport pilots.

DPPA is not likely to be a constant, but should be reflective of national economic conditions and the relative cost of aircraft ownership. Time series values for DPPA were derived from actual data

and used in a multiple regression analysis which yielded the following estimated relationship,

$$DPPA\ (1,1) = 20.0 * GNP^{-2.88}$$

Similar analyses were conducted for each of the 29 significant subsegments.

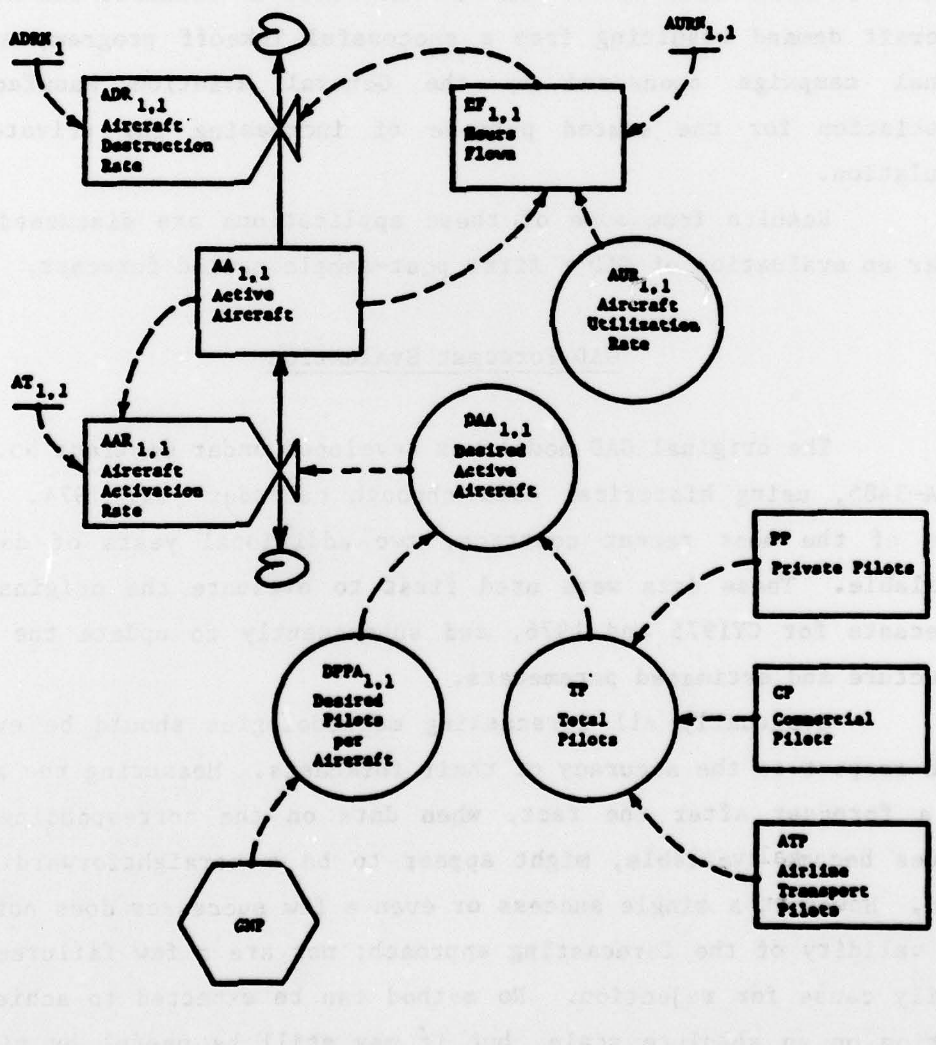

FIGURE 3. BUSINESS/SINGLE-ENGINE PISTON EXAMPLE

APPLICATIONS

The General Aviation Dynamics model has been used in a variety of applications. It has been used by the FAA to estimate the response of general aviation to rising fuel prices, additional fuel conservation taxes, and the President's FY1980 budget proposal. The Environmental Protection Agency has used GAD to evaluate general aviation's response to mandatory requirements for noise suppression controls on turbine-powered aircraft. Transport Canada used GAD in estimating the relationship between the level of general aviation flying and the variable cost of aircraft operation. GAD was also used to estimate the increased aircraft demand resulting from a successful Takeoff program, a promotional campaign sponsored by the General Aviation Manufacturer's Association for the stated purpose of increasing the private pilot population.

Results from some of these applications are discussed below, after an evaluation of GAD's first post-sample period forecast.

GAD Forecast Evaluation

The original GAD model was developed under Contract No. DOT-FA 74WA-3485, using historical data through calendar year 1974. At the time of the most recent contract, two additional years of data were available. These data were used first to evaluate the original model forecasts for CY1975 and 1976, and subsequently to update the model's structure and estimated parameters.

Eventually all forecasting methodologies should be evaluated with respect to the accuracy of their forecasts. Measuring the accuracy of a forecast after the fact, when data on the corresponding actual values become available, might appear to be a straightforward resolution. However, a single success or even a few successes does not assure the validity of the forecasting approach; nor are a few failures necessarily cause for rejection. No method can be expected to achieve perfection on an absolute scale, but it may still be useful by virtue of

its accuracy relative to other forecasting methods or its ability to explain system behavior.

A useful method for evaluating the accuracy of a forecast is the prediction-realization diagram, a simple graphical tool which can be used to readily identify both turning point errors (i.e., direction of change in a variable) and errors in the magnitude of change. On a two-dimensional diagram, predicted values are indicated on the vertical axis and actual values on the horizontal axis. Perfect forecasts would fall on a straight line through the origin at a slope of 45 degrees. The original axes and the line of perfect forecasts divide the diagram into six sections (Figure 4).

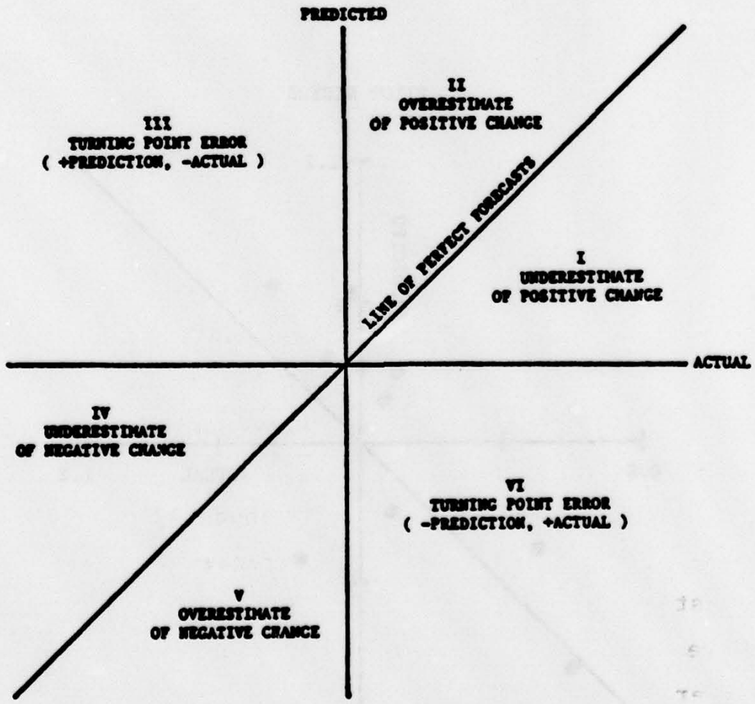

FIGURE 4. PREDICTION-REALIZATION DIAGRAM

Points falling in section I represent forecasts of a positive change, where the realization also turned out to be positive, but of a larger magnitude. Any points in section I, therefore, represent underestimates of a positive change. On the other hand, points in section II represent overestimates of a positive change. Predictions of a positive change, which actually turned out negative, are known as turning point errors and would fall in Section III. Sections IV, V, and VI possess similar characteristics for forecasts of negative change.

GAD forecasts for each type of pilot and for each user category/aircraft type subsegment were compared to actual conditions during 1975 and 1976. In general, the GAD model underestimated activity levels duirng 1975, but tended to compensate for this during the second year of simulation.

Figure 5 shows the results for each projected variable within the pilot sector. Relative changes were determined by normalizing the

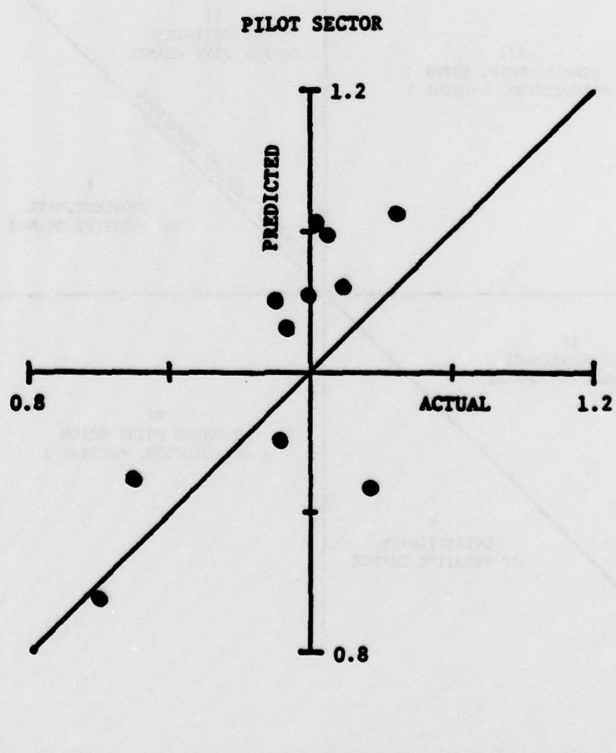

FIGURE 5. PREDICTED VERSUS ACTUAL CHANGES WITHIN THE PILOT SECTOR

value of each variable with respect to its value during 1974. GAD forecasts for active pilot population by type of certificate were generally high, primarily because of a substantial increase in the number of active pilots who let their medical certificates expire during the period. Perhaps, the new flight check requirements during the biennial review have had a significant impact.

Figure 6 shows a prediction-realization diagram of the relative changes for all variables occurring, from 1975 to 1976, the second year of simulation. This diagram indicates excellent agreement between the model forecast and reality. For the most part there are very few turning point errors, justifying the underlying structure of the model.

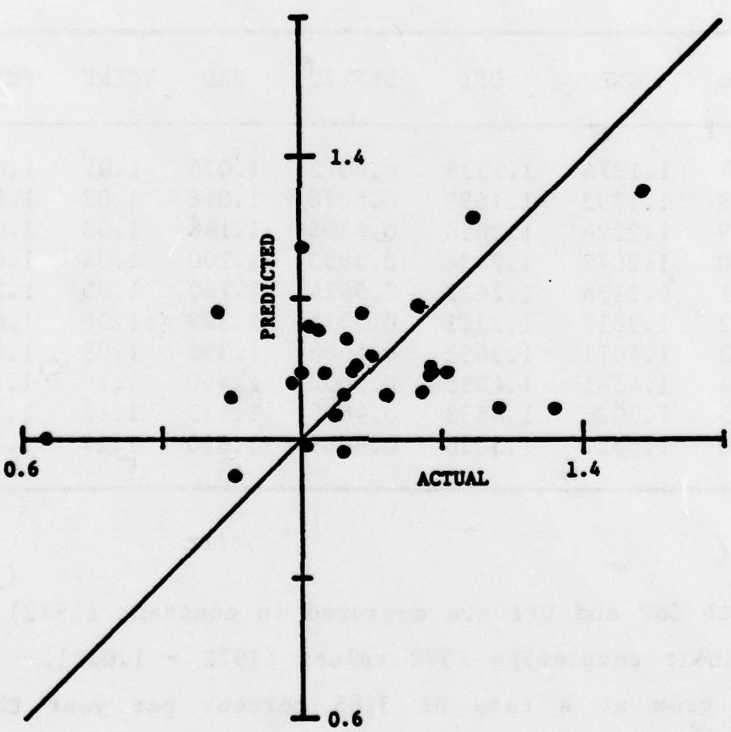

FIGURE 6. PREDICTED VERSUS ACTUAL CHANGES OCCURRING DURING 1976 FOR ALL VARIABLES

Baseline Forecast

Any long-range planning exercise must be based on a forecast of uninhibited general aviation activity. Exogenous data required for a 10-year baseline forecast are entirely self-contained within the model. Values for GNP, DPI and the current dollar deflator are consistent with those used in the "FAA Aviation Forecast Fiscal Years 1978-1979". Estimates for revenue aircraft departures, variable costs of operation and fixed costs of ownership are also representative of current FAA expectations. The values for each of these variables through CY 1986 are given in Table 3.

TABLE 3. EXOGENOUS INPUT FOR BASELINE FORECAST

Date	GNP	DPI	DEFL72	RAD	VCINF	FCINF
1977	1.1376	1.1339	0.7072	1.036	1.01	1.01
1978	1.1793	1.1693	0.6678	1.088	1.02	1.02
1979	1.2224	1.2058	0.6306	1.143	1.03	1.03
1980	1.2672	1.2434	0.5955	1.200	1.04	1.04
1981	1.3136	1.2822	0.5624	1.260	1.05	1.05
1982	1.3617	1.3222	0.5311	1.323	1.06	1.06
1983	1.4071	1.3652	0.5066	1.390	1.08	1.08
1984	1.4541	1.4095	0.4832	1.460	1.10	1.10
1985	1.5026	1.4533	0.4609	1.533	1.12	1.12
1986	1.5527	1.5026	0.4396	1.610	1.14	1.14

Both GNP and DPI are measured in constant (1972) dollars and indexed to their respective 1972 values (1972 = 1.000). Real GNP is expected to grow at a rate of 3.66 percent per year through 1982, decreasing to 3.34 percent per year afterwards. DPI was assumed to increase at the same rate as personal consumption of services--3.12 percent per year through 1982, followed by 3.25 percent per year.

Only two of the forecast tables presented in "FAA Aviation Foecasts Fiscal Year 1978-1989" can be directly compared to GAD output. These are forecasts for the number of active aircraft by type of aircraft and for the number of active pilots by type of certificate. Tables 4 and 5 are reproduced here from GAD output data and the individual entries can be compared directly to Tables 11 and 28 of the FAA's publication.

The GAD model is projecting 81,000 more single-engine aircraft, 14,000 more multi-engine aircraft, and 3,400 more rotorcraft by 1987. However, it is projecting only 600 more turbojets and 1,400 less turboprops by 1987.

Comparisons between the GAD and FAA forecasts for active pilots by 1987, show the FAA to be higher than GAD for all certificate types, except airline transport. FAA is projecting almost 60,000 more student pilots, over 100,000 more private pilots, 50,000 more commercial pilots, 2,600 more helicopter pilots, and 40,000 more instrument ratings over the next 10 years. However, the FAA estimates 10,000 less airline transport pilots than GAD. Since past FAA forecasts of active pilot populations have overestimated the actual levels, it is possible that these forecasts, if based on the same methodology and structure, could also be on the high side. The pilot sector of the GAD model is the best understood and its long-term forecasts have the highest level of confidence.

Both the FAA and GAD forecasts are conditional on the separate projections for the exogenous variables. In reality, it is hard to conceive of the U.S. economy expanding at a constant rate over the next 10 years. Even if it were to achieve the projected level for 1986, the growth would undoubtedly be cyclical about the average rate of increase. An additional consideration is the impact of GAMA's pilot promotion campaign Takeoff. There have been indications already that Takeoff is creating more student starts and increasing the completion rate to private--although not at desired levels.

TABLE 4. ESTIMATED ACTIVE GENERAL AVIATION AIRCRAFT BY TYPE OF AIRCRAFT (thousands)

		Fixed Wing				
		Piston				
As of January 1	Total	Single-Engine	Multi-Engine	Turboprop	Turbojet	Rotorcraft
1973	143.1	120.4	17.3	1.5	1.1	2.9
1974	151.3	126.2	18.7	1.9	1.4	3.1
1975	159.0	131.9	19.8	2.1	1.6	3.6
1976	165.6	136.9	20.3	2.5	1.8	4.1
1977	175.1	144.9	21.3	2.5	1.9	4.5
1978*	184.4	152.0	22.5	2.7	2.3	4.8
1979*	199.1	163.6	24.9	3.0	2.5	5.1
1980*	216.1	177.0	27.4	3.3	2.8	5.6
1981*	234.3	191.3	30.1	3.7	3.1	6.1
1982*	254.0	206.6	33.3	4.0	3.4	6.7
1983*	275.1	223.0	36.7	4.4	3.8	7.3
1984*	297.5	240.3	40.5	4.7	4.1	7.9
1985*	321.1	258.6	44.4	5.0	4.5	8.5
1986*	346.0	277.8	48.7	5.4	4.9	9.2
1987*	372.3	298.0	53.3	5.8	5.3	9.9

*Forecast.

TABLE 5. ESTIMATED ACTIVE PILOTS BY TYPE OF CERTIFICATE

As of January 1	Students	Private	Commercial	Airline Transport	Helicopter	Instrument Rated
1973	181,477	323,383	196,228	37,714	7,987	187,909
1974	181,905	301,863	182,444	38,139	5,968	185,969
1975	180,795	305,848	192,425	41,002	5,647	199,323
1976	176,978	305,867	189,342	42,592	4,932	203,954
1977	188,801	309,005	187,801	45,072	4,804	211,364
1978*	183,800	323,800	189,700	47,800	4,300	221,500
1979*	182,700	335,100	192,100	50,900	3,900	232,400
1980*	182,700	344,300	195,300	53,800	3,600	244,000
1981*	182,900	352,100	199,200	56,700	3,300	256,000
1982*	183,200	358,500	203,600	59,500	3,100	268,300
1983*	182,600	363,800	208,300	62,500	2,900	281,000
1984*	179,900	368,200	213,200	65,400	2,600	293,500
1985*	177,000	371,200	217,900	68,400	2,400	305,900
1986*	174,100	372,900	222,600	71,400	2,200	318,100
1987*	171,300	373,500	227,200	74,400	2,000	330,000

*Forecast.

FY1980 Federal Budget Proposals

President Carter, in his 1980 budget request, has asked for increased user charges to be imposed on general aviation. If approved, the current seven-cent tax on general aviation fuel would be changed to an ad valorem tax equal to ten percent of the price of aviation fuel. In addition, a six percent excise tax on new general aviation aircraft and avionics is being requested.

If the intent of these proposals is to recover the costs of operating and maintaining the Federal airport and airway system, then the response (price elasticity) of general aviation is crucial to recovering the anticipated tax revenues. If an increase in tax rate resulted in significantly reduced levels of general aviation (elasticity much greater than one), then the revenues collected could actually decrease - directly opposite the intention, and hence a self-defeating proposition.

The FAA has used the GAD model to provide answers to these questions. Table 6 shows the reductions in general aviation activity levels that could be expected (for select years) under these proposals.

TABLE 6. ESTIMATED REDUCTIONS IN GENERAL AVIATION ACTIVITY UNDER FY1980 FEDERAL BUDGET PROPOSAL (percent reductions from baseline)

	During the Year 1980	1983	1986
Active Aircraft	-	-0.34	-0.72
Hours Flown	-0.29	-0.57	-0.93
Operations	-0.39	-0.73	-1.12
Pilots	-0.33	-0.70	-1.45

If fuel prices were to increase at the presently expected rate of seven percent per year, the President's proposal would result in a federal fuel tax of approximately 10, 13, and 16 cents per gallon by 1980, 1983, and 1986, respectively. The increase in federal revenue collected, from fuel taxes alone, would be $40 million in 1980, $100 million in 1983, and nearly $200 million by 1986.

Even though general aviation activity would be reduced slightly, the federal revenue collected from general aviation would increase dramatically. General aviation's response to these proposals is expected to be quite inelastic.

CONCLUSIONS AND RECOMMENDATIONS

The General Aviation Dynamics model represents a significant advance in understanding the complex behavior within the general aviation system. It offers the FAA a tool for producing absolute *forecasts and evaluating alternative policy actions.* GAD will be useful in analyzing system behavior, designing practical policy options, and evaluating their long-term implications. On-line use renders the GAD model accessible by virtually anyone.

This first post-sample period evaluation of the GAD model verifies its usefulness. Although the absolute forecasts were not precise, it was possible to return to the model's structure and adequately explain the deviations. It is unlikely that a classical econometric model would have been able to provide such insight.

Every new forecasting method needs time to become accepted. Presently, GAD is being used more in a role of policy evaluation, by identifying changes in future activity under alternative scenarios, rather than producing absolute forecasts. Yet when compared to FAA forecasts for the same time period, the GAD model was definitely better in predicting active pilot populations and about as good in predicting aggregate levels of general aviation aircraft by type of aircraft. GAD's advantage is in being able to study general aviation behavior at

the micro-level. Forecasts for activity within individual user category/aircraft type subsegments are much more valuable in evaluating long-term plans and policies.

Still, there are parts of the GAD model which are more thoroughly understood than others. The air taxi user category, including commuter airlines, and the turboprop aircraft types are the two areas needing additional research in order to better understand their recent phenomenal growth rates. Certainly, provisions should be made for periodically evaluating the GAD model's predictions and revising its parameter estimates as future data become available. In applying the model to problems other than those for which it was designed, it may be necessary to introduce modifications, append additional sectors, and elaborate some sectors already in the model. The basic approach has been demonstrated; future applications are numerous.

Note: To obtain additional information concerning Volume III, Systems Manual, contact the Aviation Forecast Branch, AVP-120, Federal Aviation Administration, Washington, D.C. 20591, Phone (202) 426-3103.

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